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A Novel Approach for Soil Testing using Embedded System

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Abstract: At present many analytical laboratories that provide a chemical soil testing service, some are woefully inadequate testing only for phosphorus, potassium, pH and salinity and ignoring all other nutrients. Others can be very comprehensive but the results badly presented. This makes it difficult for the farmer in particular to make any sense out of his own soil test and puts his decisions regarding fertilizer firmly in the minds of the "experts" who are also often the manufacturers/sellers of particular types of fertilizer. Our main objective is to develop a testing system which can be used for soil analysis, which in term helps the farmers to grow and produce the proper crop that can be a feedback to the farmers to implement "precision agriculture". The System measures Nitrogen, Potassium, Phosphorous and PH of soil. In the system, nitrate and phosphorous ISE are used to measure concentration of N and K nutrient of soil.

Keywords: Electrical conductivity, Nitrate ISE, Phosphorus ISE, Precision Agriculture.

INTRODUCTION

Indian economy is mainly based on agriculture; still we are not able to make most Favorable, commercial and sustainable use of our land resources. The main reason is the lack of knowledge regarding the soil analysis for the growth of crops. The history of the farmer started intensive cultivation of early-maturing, high yielding varieties without paying much attention to the soil-nutrient status and soil health. In every state, around 9 to 10 lakhs soil samples have been received in laboratories and it is very difficult to test all the soil samples at a time by the laboratories. It takes more time to generate test reports. Hence there is a need for soil analysis to be made available to the farmer.

Optimum nutritional conditions can vary for different crops and for same crops at different times of their life cycle. For the same crops at different times of the year and the same crops under different environmental conditions. The pH and EC (electrical conductivity) are the two important indices of fertigation. They represent the whole quality and characteristics of fertilizers and water. It varies for different plants and soils.

A standard soil testing procedure and a standard method of reporting is badly needed. Also a reasoned interpretation of soil test results can only be made if other information about the soil is made available. In determining the fertility status of the soil consideration must be given to the three major components of soil fertility:

- The physical characteristics of the soil
- The biological status of the soil
- The chemical status of the soil

All these major factors interact with each other. The unfortunate trend of the last 70 years has been to use fertilizers to feed the plant rather than to feed the soil. A fertile soil will grow excellent healthy crops with good disease and pest resistance. Trying to feed crops directly may give some spectacular results but almost inevitably results in imbalances that result in unsound growth and increased postharvest problems. This places the farmer on the treadmill of continued and increasing reliance on chemical fertilizers, fungicides, pesticides and animal health remedies.

If the soil has high salinity content, the plants growing there will not be as igorous as they would be in normal soils. Seeds will germinate poorly, if at all, and the plants will grow slowly or become stunted. If the salinity concentration is high enough, the plants will wilt and die, no matter how much we water them.

Routine soil testing can identify the soil's salinity levels and suggest measures that can be taken to correct the specific salinity problem in the soil.

Soil analysis is a valuable tool for the farm as it determines the inputs required for efficient and economic production. A proper soil test will help ensure the application of enough fertilizer to meet the requirements of the crop while taking advantage of the nutrients already present in the soil. It will also allow us to determine lime requirements and can be used to diagnose problem areas. It is very important that our sampling technique is correct as the results are only as good as the sample we take. Soil testing is also a requirement for farms that must complete a nutrient management plan.

LITERATURE SURVEY

Hung-Yuan Chung (2014),[1] "Agricultural monitoring system based on ant colony algorithm with Centre data aggregation" This paper proposed environmental

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parameters are collected by use of outdoor ZigBee based weather stations as a prerequisite for the optimization of plant growth. In most cases, all the sensors required are integrated into a weather station, due to which merely a single monitoring node is employed following data aggregation. An energy efficient center data aggregation algorithm, where an ant colony algorithm is applied to the construction of a level gradient held, is presented as an effective way to extend the life cycles of sensor nodes. A weather station and a ZigBee module both are portable and easy to install battery operated devices. Furthermore, a remote web-based human machine interface (HMI) is developed by InduSof on a server, and has an access to a database. This proposed algorithm is confirmed by computer simulations as an effective approach to remarkably extend the life cycles of sensor nodes. This work can be applied not merely to traditional outdoor large scale farming, but also to small scale indoor plantation, e.g. in a green house, a plant factory, etc., and applied to the help of conservation ecology.

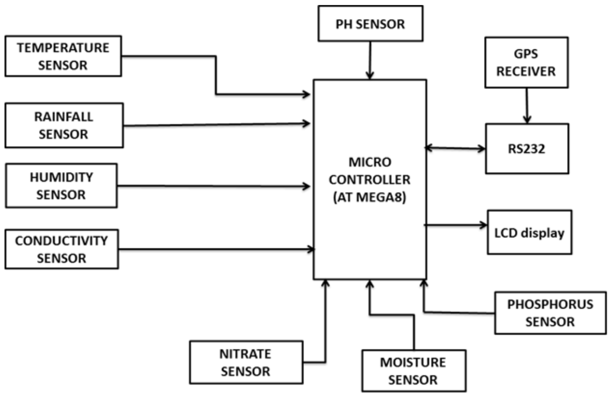
lB. Balaji Bhanu (2014)[2]: "Monitoring of Soil Parameters for Effective Irrigation using Wireless Sensor Networks" WSN (Wireless Sensor Network) has attracted the attention of researchers due to its wide applicability to various fields such as disaster management, health and environment monitoring, agriculture, ecology, industrial automation and in military field applications like battlefield surveillance etc. In agricultural ecosystem -situ - continuous smart monitoring of soil parameters like humidity, pH, irrigation control systems etc. can be measured using WSN with high end precision. In this manuscript, we propose to develop a WSN based Dynamic and Automated Irrigation System design and instrumentation. This process maintains soil type and Software for real time sensing and control of agricultural irrigation system. The efficiency of irrigation systems can be enhanced by automated remote sensing and continuous analysis of soil parameters. Thus the data acquired is useful to the agricultural sector, namely pest management, irrigation management and soil management. Ultimately, this reduces the fresh water consumption and irrigation costs by maximizing the crop yield.

Zhikai Chang (2013) [3]: "Measurement Experiment and Mathematical Model of Nitrate Ion Selective Electrode**"**Compared with conventional laboratory chemical analysis, ion selective electrode (ISE) is time-saving, low-cost, ease of use and pollution-free. To detect soil nitrate nitrogen content rapidly, a nitrate ion selective electrode could be used. This paper studied characteristics of nitrate ISE. Potentiometric experiments utilizing nitrate ISE to measure sodium nitrate solution were conducted during the study. A linear regression model based on the Nernst equation was built using the least square method. Several groups of potential values were measured at one concentration and then the arithmetic mean of them was calculated. These mean values and their corresponding concentrations were used in LSM to reduce the impact of the relatively poor repeatability of ISE and reduce nitrate concentration prediction errors. The feasibility of the modeling method was verified using prediction errors as an index. In this study, extra data points except the calibration points were used to test the prediction error. Except several singular points, the relative error of this model was from 1.3% to 13.67% (absolute value). Compared with calibration each time, this modeling method can be used to determinate the nitrate concentration if ISE will be calibrated after using for a certain number of times.

PROPOSED SYSTEM

Block diagram:

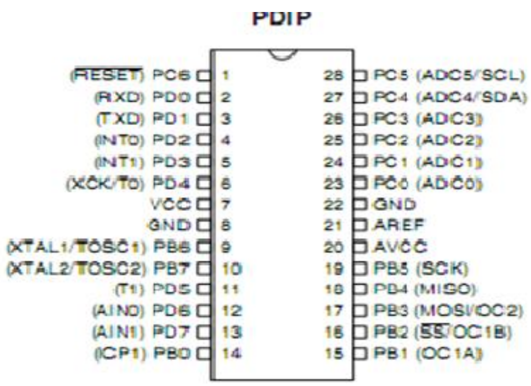
The proposed system is used to measure the amount of fertilizer that is given in our land. By measuring the raw soil by the use of sensors we can calculate the parameters such as rainfall, temperature, humidity and conductivity and NPK range. The overall process involves (i) Sensing the amount of available nutrients in soil. (ii)Sensing the environmental factors. (iii)To calculate the amount of fertilizer needed for particular crop. (iv)At abnormal stages a message will be send to the farmer through GSM. (v)Stores the results for future use.



System Description:

Microcontroller

Pin configuration:



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The pH sensor, Electrical Conductivity sensor, Nitrate and Phosphorous ion selective electrodes are interfaced to the microcontroller**.** The final amount of nitrogen ions and phosphorous ions which are present in the soil are displayed through LCD.System measures nitrogen, phosphorous, pH and electrical conductivity of soil and system gives result that how much amount of fertilizers need for soil. It takes less time to give report. System is very cheap as compared to soil testing laboratory. It improves fertility of soil and therefore will be increased crop yield.

Sensor Unit:

i) pH sensor

Soil pH is a key parameter for crop productivity, therefore, its spatial variation should be adequately addressed to improve precision management decisions. As a measure of soil acidity or alkalinity, soil pH constitutes one of the most important chemical soil parameters. Generally, soil pH values outside the range of 5.5 to 6.5 are considered as non-optimum because they can have negative impacts on nutrient availability, soil structure, soil organisms, and can make plants more sensitive to diseases. Due to uptake by plants and natural leaching of alkaline soil compounds, acidification is common among soils in temperate climates. Fewer soils, like soils on limestone or on glacial till, have high pH values. The regulation of soil pH by applying alkaline or acid fertilizers can limit effects of extreme acidic or alkaline soil conditions, which in turn improves crop production and resource efficiency. In a global view, soil pH regulation becomes a vital strategy within a radically changing world, where globally average crop yields must be increased by 60% to 120% until 2050 to meet the needs of the human population and dietary habits soil alkalinity (high pH) is more common in low rainfall areas of the West. Low soil pH causes aluminum and manganese toxicity in plants and reduces the availability of soil phosphorus. High soil pH also reduces soil phosphorus availability and reduces micronutrients such as zinc and boron to plants. pH gives the information of acidity or alkalinity of solution. It is measured on a scale of 0-14. pH reading of a solution below value 7 is considered acidic, while a pH reading above the value 7 is consider as basic. A pH reading of 7 is neutral because there are equal concentrations of (H+) and (OH-) is ideal for many plants and spray materials. pH level gives the availability of nutrients in the soil or fertilizer solution . pH range of fertilizers solution delivered in soil affects the soil properties. Calcium, Phosphorus, potassium and magnesium are unavailable to plants in acidic soil. Plants have difficulty in absorbing micronutrients like copper, zinc, boron, manganese and iron in basic soils; however their presence in soil can also be excessive and become toxic to plants.

ii) Electrical Conductivity sensor

Salinity of solution is measured by common way using electrical conductivity (EC) sensor. This sensor measures the electricity moves through a saltier solution, the electricity moves through it is directly proportional to the conductivity readings. EC is measured in ds/cm (DeciSiemens per centimeter). In all soils salts are naturally present additional salts build up in the soil by higher concentration of fertilizers applied. Under irrigation and inadequate drainage is also one of the cause of soil salinity. The salt concentration in the soil restricts a plant's ability to take up water from the soil. The higher EC value has toxic effect on plant's metabolism. EC affects the physical structure of soil. Salinity has positive effect in terms of soil aggregation and negative effect on plant's growth.

Ion Selective Electrode

The main objective of this system is to measure Nitrogen and Phosphorous ion concentration into the soil. Nitrogen andPhosphorous are the macronutrient of soil. Standard laboratory methods for measurement of soil nitrate (NO3–N) use various procedures and instruments to analyze soil samples taken from the field and transported to the laboratory. Concerns with these procedures range from delays in measurement time, the high cost of soil sampling and analysis, labor requirements, and the need to aggregate samples. With recent advances in using the ion-selective electrode, as presented in this project, soil NO3–N can now be measured directly, rapidly, accurately, at low cost, at a fine scale, and in real-time right in the field. Nitrogen is taken up by plant in the form of nitrate. Nitrogen is inert gas which constitutes in 78% of the atmospheric air. Nitrogen is basic nutrient it forms chlorophyll, amino acid and proteins. When the plant takes up large quantities of nitrogen from the soil then the color of the plant changes to dark green, indicating that the increase of chlorophyll in the plant. Excess of nitrogen supplies to plant compared with other nutrients, the extra protein produced enlarges the leaves which provides larger leaf surface for photosynthesis and makes the leaves less coarse, increases the length of the growing season and delays maturity. But when the crop plants become more succulent due to larger availability of nitrogen they become susceptible to Pests and diseases. Source of Nitrogen to plant are from free living organism, organic matter in soil, rain water and Nitrogenous chemical fertilizers.

Features of Nitrate ISE

a) Range 1to 10,000mg/L

b) Accuracy +-10% of full scale

c) pH range 2.5 to 11

d) Electrode resistance 1 to 4 MΩ

e) Temperature range 0 to 500 C.

Nitrate sensor:

The HI 4013 and HI 4113 nitrate electrodes are potentio metric devices used for the rapid determination of free nitrateions in water, emulsified foods and plant samples. The electrode functions as a sensor or ionic conductor.

The HI 4013 requires a separate reference electrode to complete its electrolytic circuit. The HI 4113 is a combination electrode with a Ag/AgCl reference electrode with gel stabilized Cl- electrolyte in its inner chamber. The external reference Chamber is refillable. The PVC membrane used on the sensor is impregnated with the organic ion exchanger. This organic ion exchanger is considered a carrier ionosphere in that it is capable of shielding and carrying the charge d-nitrate ion in its polar cage freely through the a polar Regions of the membrane. A charge imbalance develops between the test solution and internal cell of the sensor. This voltage changes in response to the sample's ion activity. When the ionic strength of the sample is fixed, the voltage is proportional to the concentration of nitrate ions in Solution.

The sensor follows the Nernst Equation:
E = Ea+ 2.3 RT/nF log A ion
E = observed potential
Ea= Reference and fixed internal voltages
R = gas constant (8.314 J/K Mol)
n = Charge on ion (-1)
A ion= ion activity in sample
T = absolute temperature in K
F = Faraday constant (9.648 x 104 C/equivalent)

PHOSPHORUS SENSOR:
Phosphorous is an essential plant nutrient important for root development, tillering, early flowering, and ripening. It is mobile within the plant, but not in the soil.

P Fertilizer Sources and Fertilizer p2o5 Equivalents

		Fertilizer P2O5 (kg ha-1)				
P fertilizer	**% P2O5**	15	20	30	40	60
		Amount of fertilizer required (kg ha-1)				
Single super	16-18	88	117	176	234	352
Double super/SP36	36	42	56	84	112	68
Triple super	44-46	33	44	66	88	132
Diammonium phosphate (DAP)	44-46	33	44	66	88	132

Uptake of NPK to Produce 1ton of grain Perhectare:
The following table shows the uptake of NPK to produce 1ton of grain per hectare. Here we have taken four field crops for example and their range of NPK uptake is given as follows,

NPK range/crops (kg/hectare)	Rice	Maize	Groundnut	Tapiaco
Nitrogen	15-20	15-20	20-25	70-90
Phosphorus	2-3	5-10	65-75	80-90
Potassium	15-20	5-10	30-37.5	200-240

Formula to Calculate the Amount of Fertilizer:

$$Amount\ of\ fertilizer = \frac{Recommended\ rate\ (kg\ nutrient\ ha^{-1})\ X\ Area\ (ha)}{\%\ nutrient\ in\ commercial\ fertilizer}\ X\ 100$$

Amount of Urea = $\frac{90 X 400}{46 X 10,000}$ X 100 = **7.8 kg** (Assuming 46% N in Urea)

Amount TSP = $\frac{60 X 400}{20 X 10,000}$ X 100 = **12 kg** (Assuming 20% P in Triple Super Phosphate)

Amount of MP = $\frac{30 X 400}{50 X 10,000}$ X 100 = **2.4 kg** (Assuming 50% K in Muriate of potash)

Amount of Zinc sulfate = $\frac{15 X 400}{36 X 10,000}$ X 100 = **1.7 kg** (Assuming 36% Zn in ZnSO4)

Amount of Gypsum = $\frac{10 X 400}{18 X 10000}$ X 100 = **0.6 kg** (Assuming 18% S in Gypsum)

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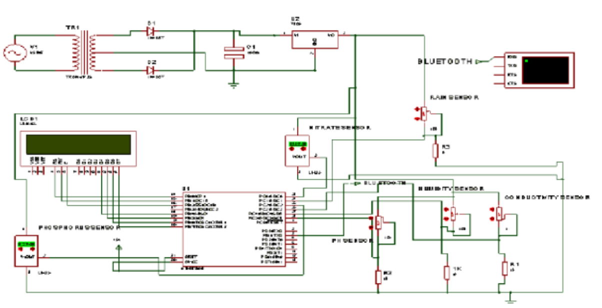
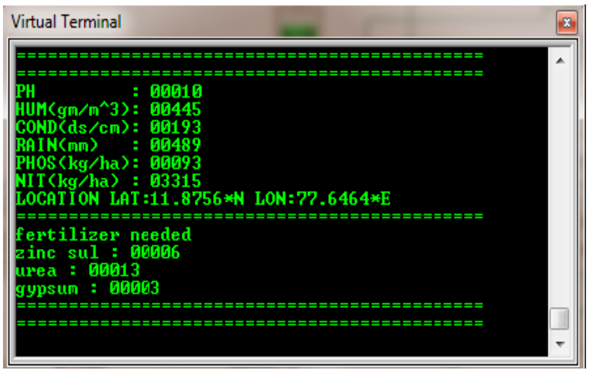
Temperature Sensor:
The temperature sensor senses the temperature of the soil. As temperature plays major role in crop growth. In this system we are making use of the sensor LM35 series. The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in ° Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling. The LM35 does not require any external calibration or trimming to provide typical accuracies of ±¼°C at room temperature and ±¾°C over a full -55 to +150°C temperature range. Low cost is assured by trimming and calibration at the wafer level. The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It can be used with single power supplies, or with plus and minus supplies. As it draws only 60 μA from its supply, it has very low self-heating, less than 0.1°C in still air. The LM35 is rated to operate over a -55° to +150°C temperature range, while the LM35C is rated for a -40° to +110°C range (-10° with improved accuracy). The LM35 series is available packaged in hermetic TO-46 transistor packages, while the LM35C, LM35CA, and LM35D are also available in the plastic TO-92 transistor package. The LM35D is also available in an 8-lead surface mount small outline package and a plastic TO-220 package.

Simulation Circuit:



Simulation Results:
The below is the output of simulation for the proposed system,



Comparison with the Existing System:
The existing system is a time consuming one, the soil samples can be taken only in few areas, and Soil testing centers are available only in limited numbers. The soil sample may take some time to reach the laboratory which results in change in the physical properties of the soil and the soil sample to be tested must be not in its original state, it has to be ionized for testing.
Whereas the proposed system eliminates all the above drawbacks, instead of taking soil samples we directly make use of the sensors in the field itself for measuring various parameters and a real time monitoring of the farm is made throughout the whole period of the growth of the crops.

CONCLUSION

Soil analysis is a valuable tool for the farm as it determines the inputs required for efficient and economic production. A proper soil test will help ensure the application of enough fertilizer to meet the requirements of the crop while taking advantage of the nutrients already present in the soil. It will also allow us to determine lime requirements and can be used to diagnose problem areas. . Soil testing is also a requirement for farms that must complete a nutrient management plan.

REFERENCES

[1] Kevin J Sibley, Gordon R Brewster, Tessema Astatkie, John F Adsett, "In-Field Measurement Of Soil Nitrate Using An Ion-selective Electrode"
[2] Yogita Kulkarni, Dr. Krishna K Warhade, Dr. Susheelkumar Bahekar, "Primary Nutrients Determination in the soil using UV Spectroscopy" may 2014
[3] BaljitKaur, Dilip Kumar, "Development of Automated Nutrients Composition control Fertigation System" June 2013
[4] V.I Adamchuk, J.w. Hummel, M.T Morgan, S.K Upadhyaya, "On-the-go soil sensors for precision agriculture"